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Norimatsu

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[54] **ELECTRONIC MUSICAL INSTRUMENT HAVING PLAYING AND PARAMETER ADJUSTMENT MODES**

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[73] Assignee: **Yamaha Corporation, Hamamatsu,** Japan

[21] Appl. No.: **184,602**

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Apr. 22, 1987 [JP] Japan 62-100773
Apr. 22, 1987 [JP] Japan 62-100774

[51] **Int. Cl.**[4] **G10H 1/18;** G10H 3/18

[52] **U.S. Cl.** **84/722;** 84/DIG. 30; 84/727

[58] **Field of Search** .... 84/1.16, 1.18, DIG. 30

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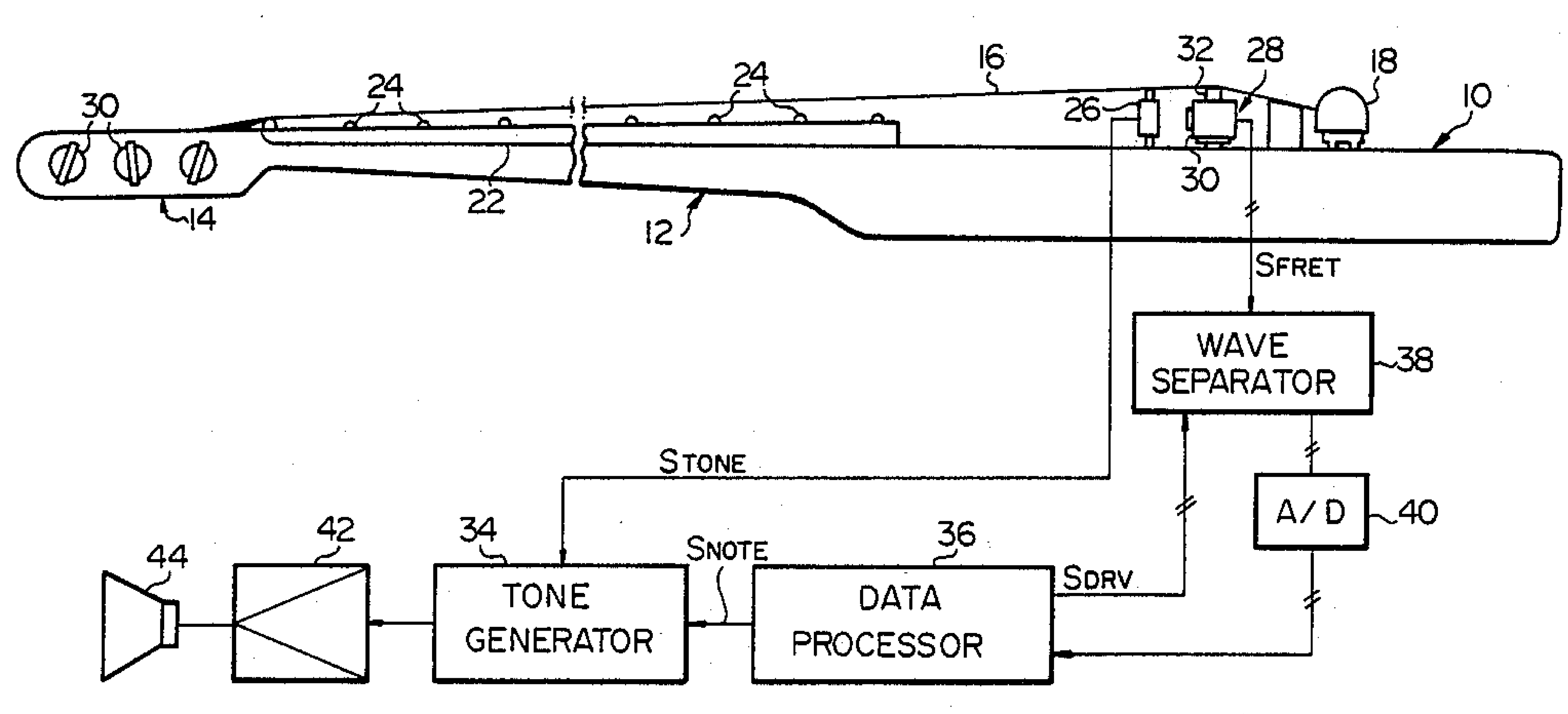
Primary Examiner—Stanley J. Witkowski
Attorney, Agent, or Firm—Burns, Doane, Swecker & Mathis

[57] **ABSTRACT**

An electronic musical instrument including fret members located at predetermined spacings, a string stretched over the fret members and contactable with any of the fret members when depressed by a player, a fret-position detector for producing supersonic vibrations in the string and receiving the supersonic vibrations reflected from any of the fret members through the string, the supersonic vibrations transmitted from the fret-position detector being reflected from a fret member contacted by the string, wherein the fret member contacted by the string is detected on the basis of a threshold value and or a reference time interval determined in respect of the string responsive to the supersonic vibrations transmitted from and reflected to the fret-position detector during a parameter adjusting mode of operation. The instrument may further include a bent-string detector for detecting an amount of lateral displacement of the string on any of the fret members and producing data representative of the detected amount of displacement of the string, wherein the amount of displacement of the string detected during a playing operation is compared with data representative of the amount of displacement detected with the string maintained in a non-bent state for producing bent-string data representative of a corrected amount of displacement of the string.

4 Claims, 8 Drawing Sheets



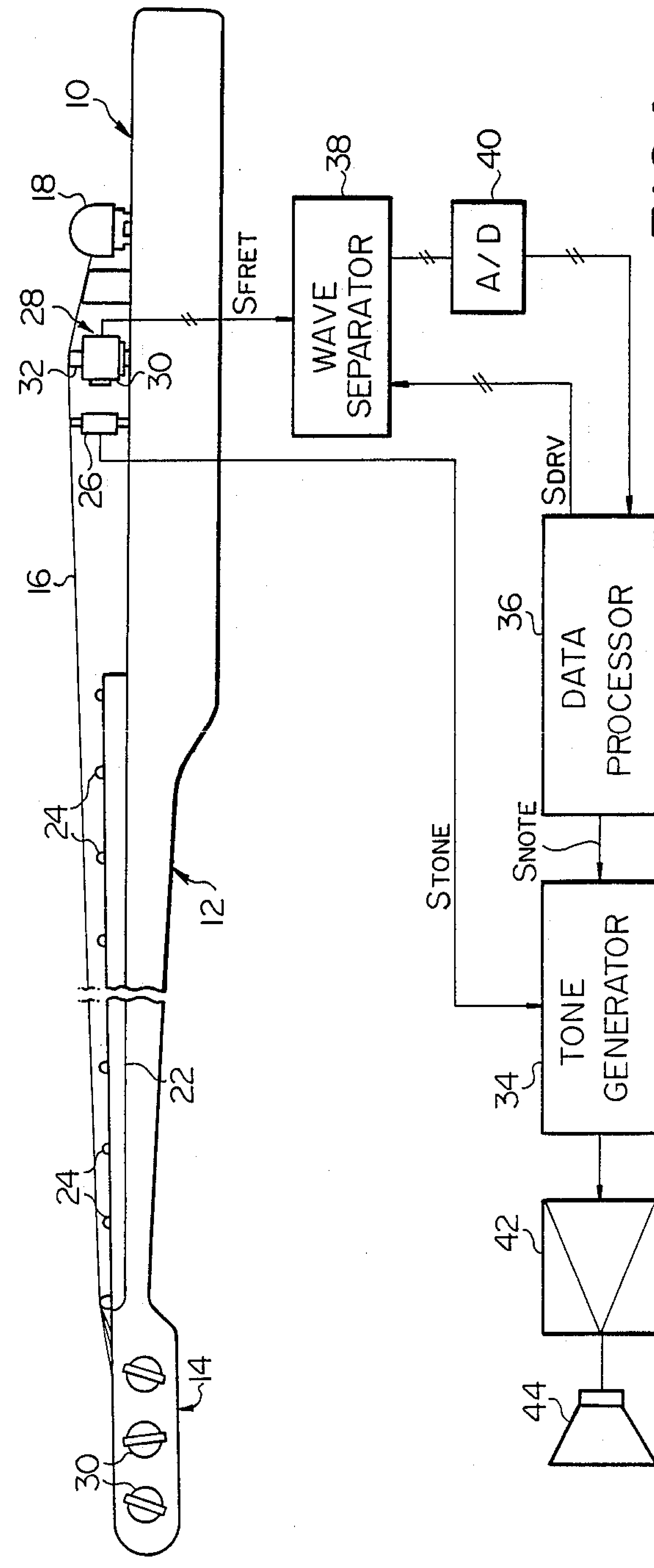

WAVE SEPARATOR
A/D
DATA PROCESSOR
TONE GENERATOR
SFRET
SDRV
SNOTE
STONE
10
12
14
16
18
22
24
26
28
30
32
34
36
38
40
42
44

FIG. 1

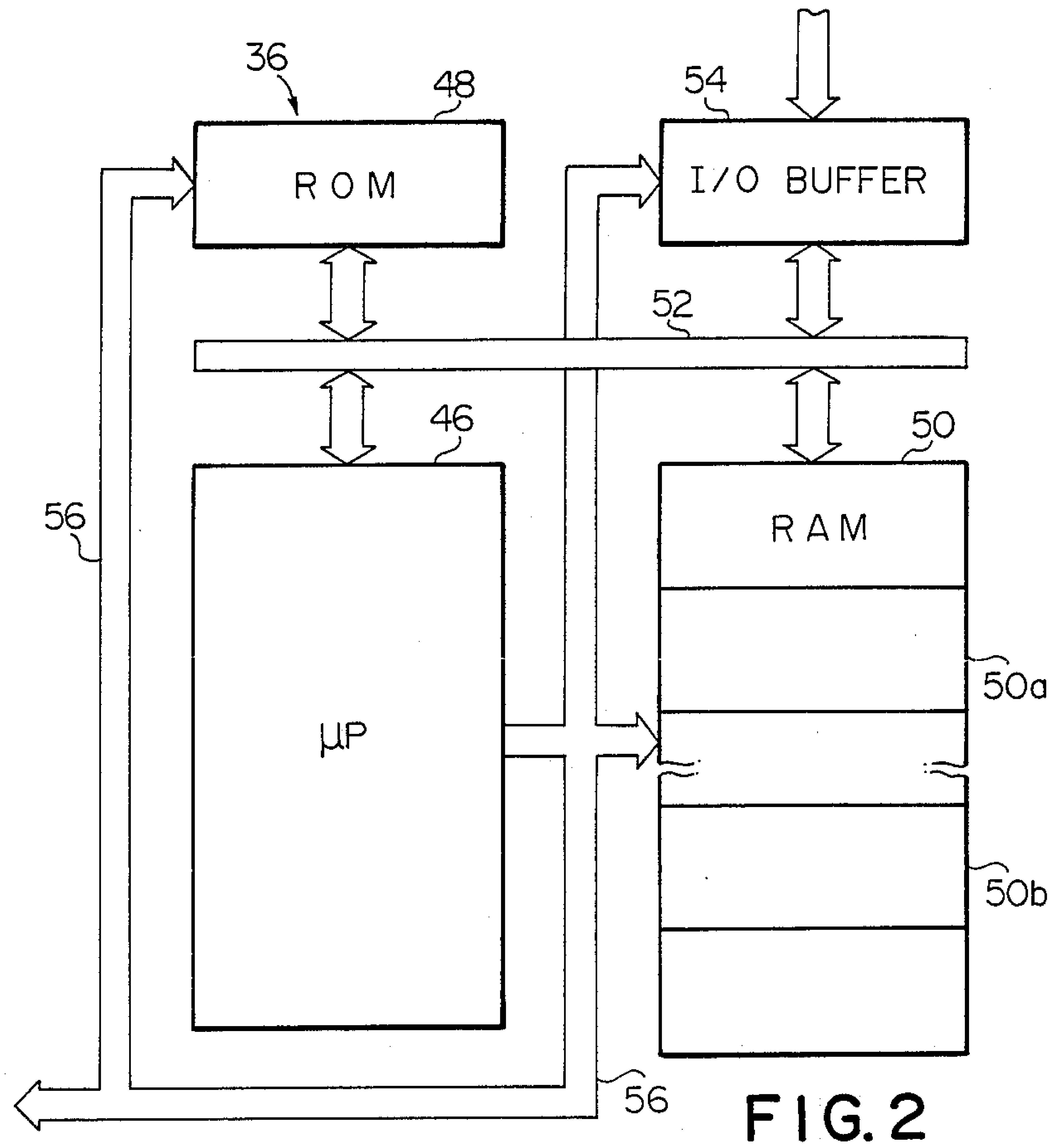


FIG. 2

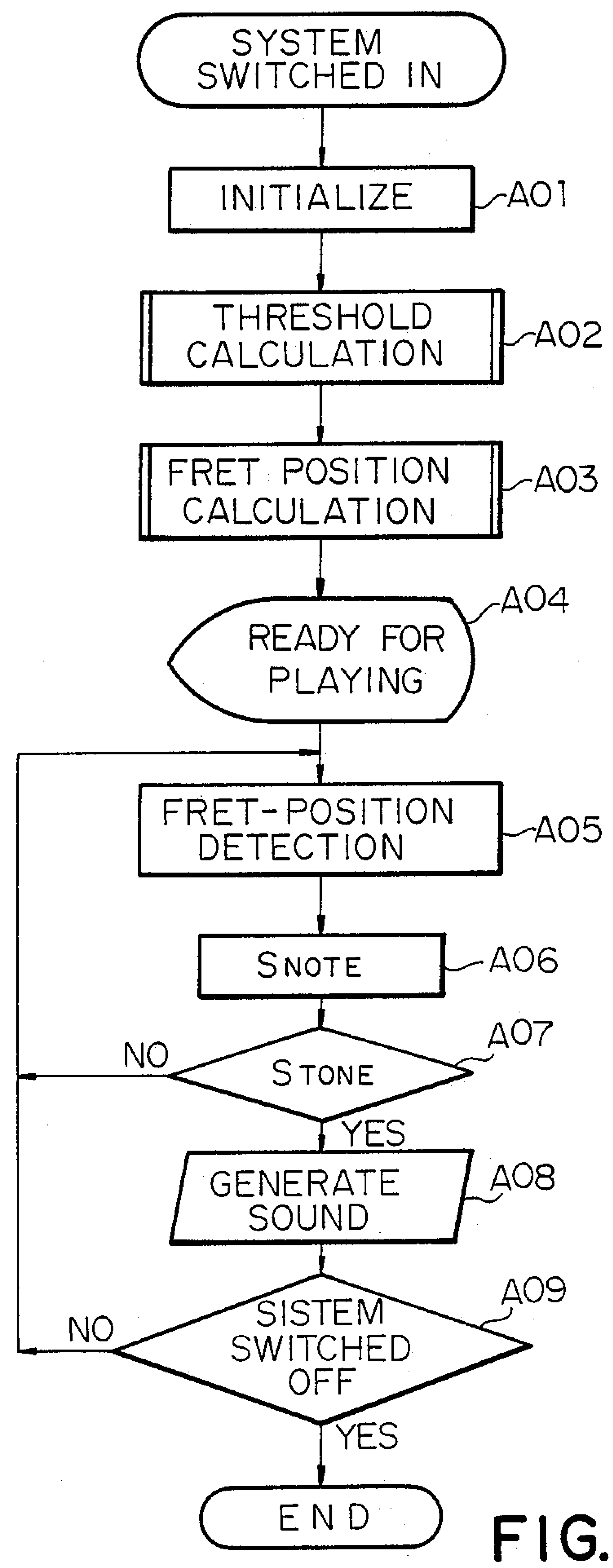

SYSTEM SWITCHED IN
INITIALIZE
A01
THRESHOLD CALCULATION
A02
FRET POSITION CALCULATION
A03
READY FOR PLAYING
A04
FRET-POSITION DETECTION
A05
SNOTE
A06
STONE
A07
NO
YES
GENERATE SOUND
A08
SISTEM SWITCHED OFF
A09
NO
YES
END

FIG. 3

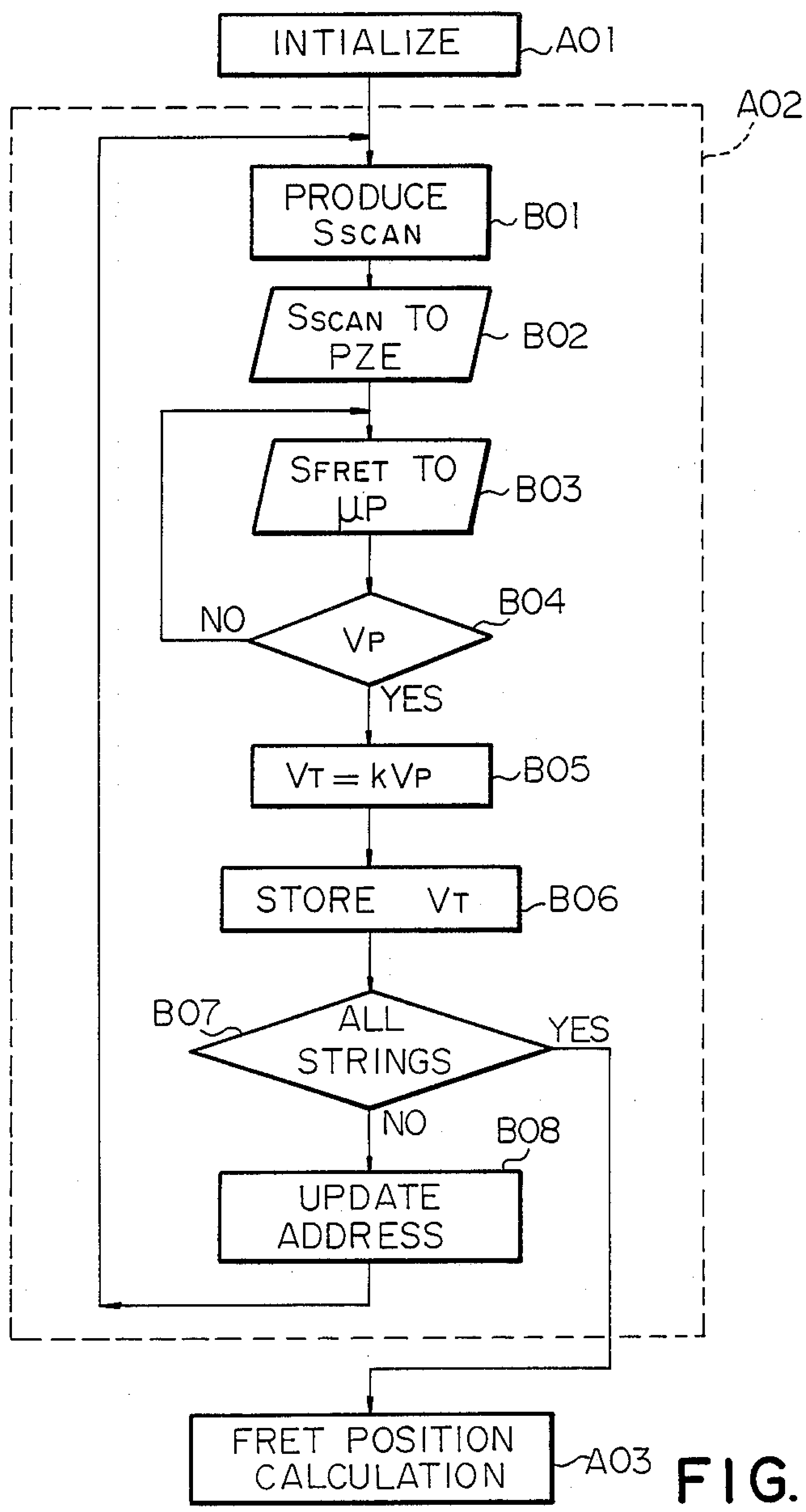

INTIALIZE
A01
A02
PRODUCE SSCAN
B01
SSCAN TO PZE
B02
SFRET TO μP
B03
NO
VP
B04
YES
VT = kVP
B05
STORE VT
B06
B07
ALL STRINGS
YES
NO
B08
UPDATE ADDRESS
FRET POSITION CALCULATION
A03

FIG. 4

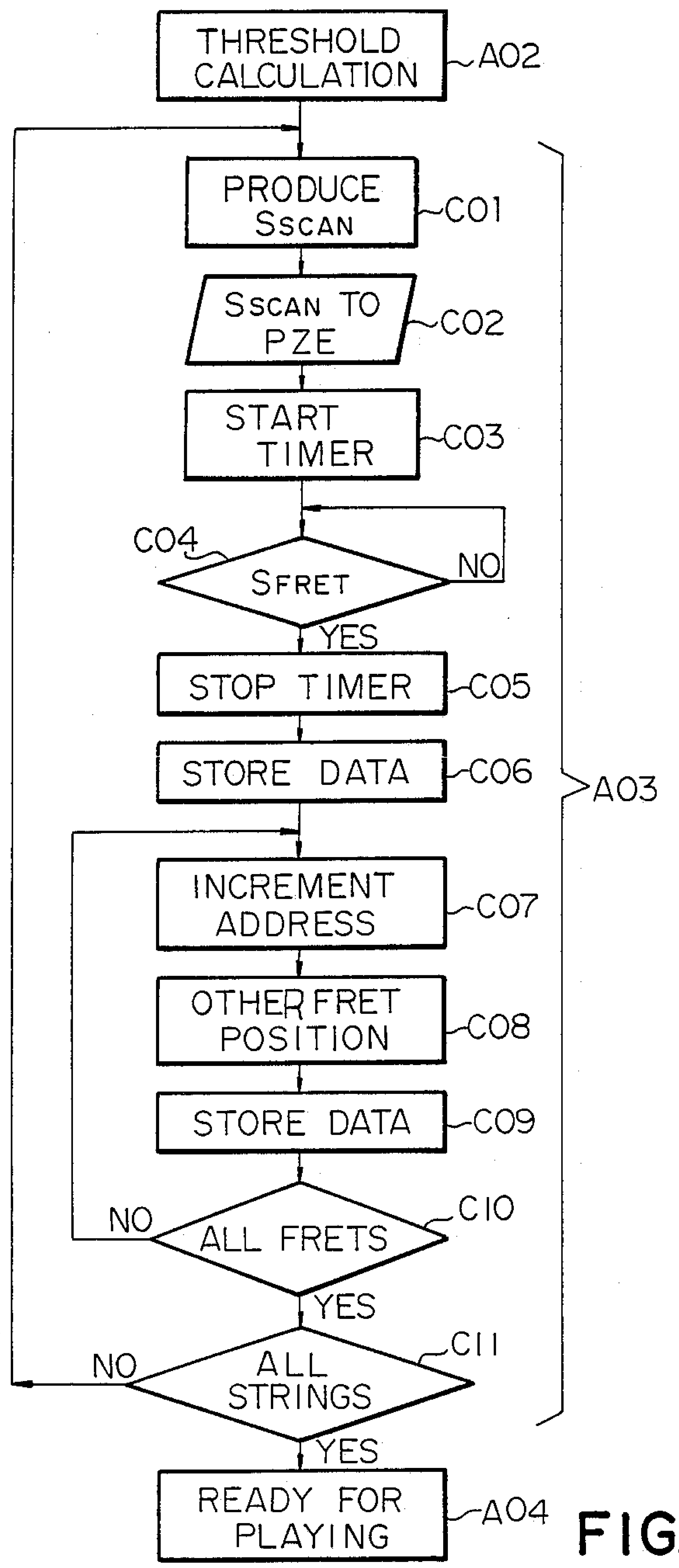

THRESHOLD CALCULATION
A02
PRODUCE SSCAN
C01
SSCAN TO PZE
C02
START TIMER
C03
C04
SFRET
NO
YES
STOP TIMER
C05
STORE DATA
C06
A03
INCREMENT ADDRESS
C07
OTHER FRET POSITION
C08
STORE DATA
C09
NO
ALL FRETS
C10
YES
NO
ALL STRINGS
C11
YES
READY FOR PLAYING
A04

FIG. 5

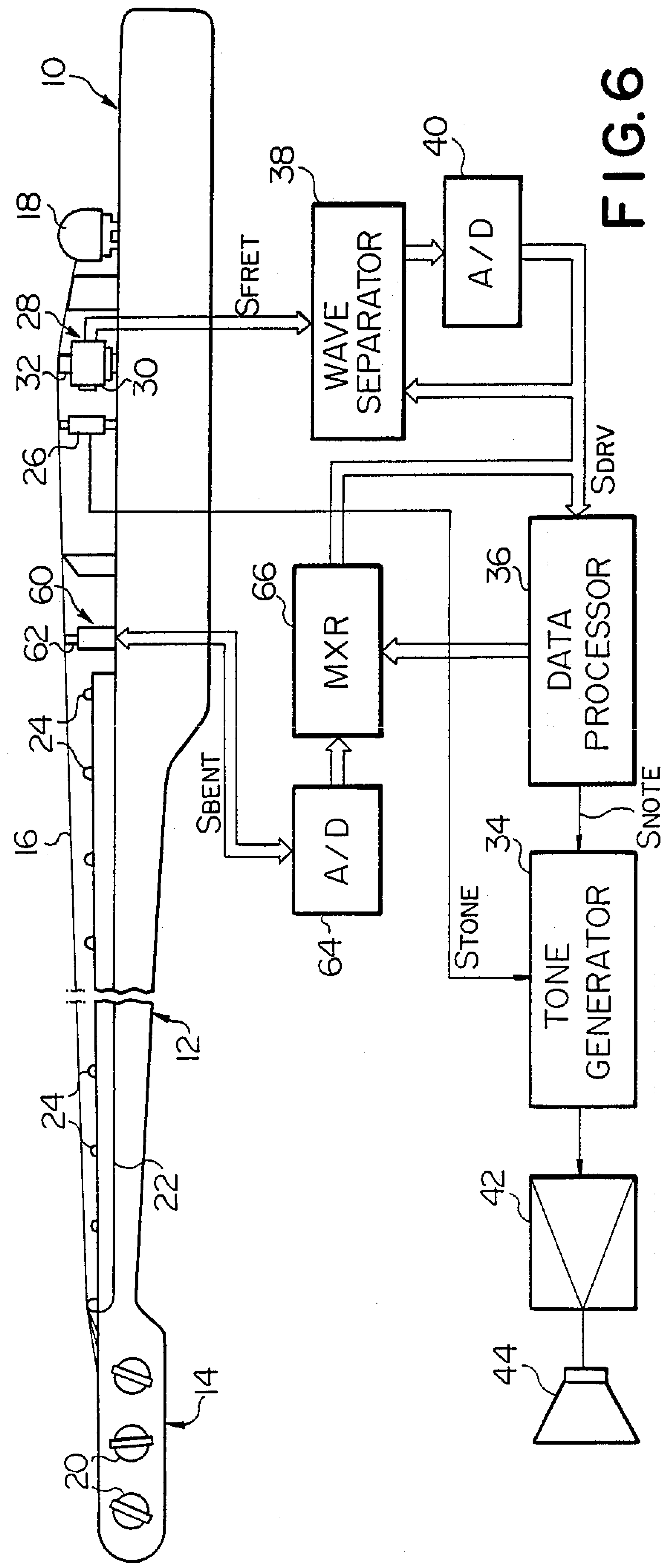

WAVE SEPARATOR
A/D
SFRET
SDRV
MXR
DATA PROCESSOR
SBENT
A/D
SNOTE
STONE
TONE GENERATOR

FIG. 6

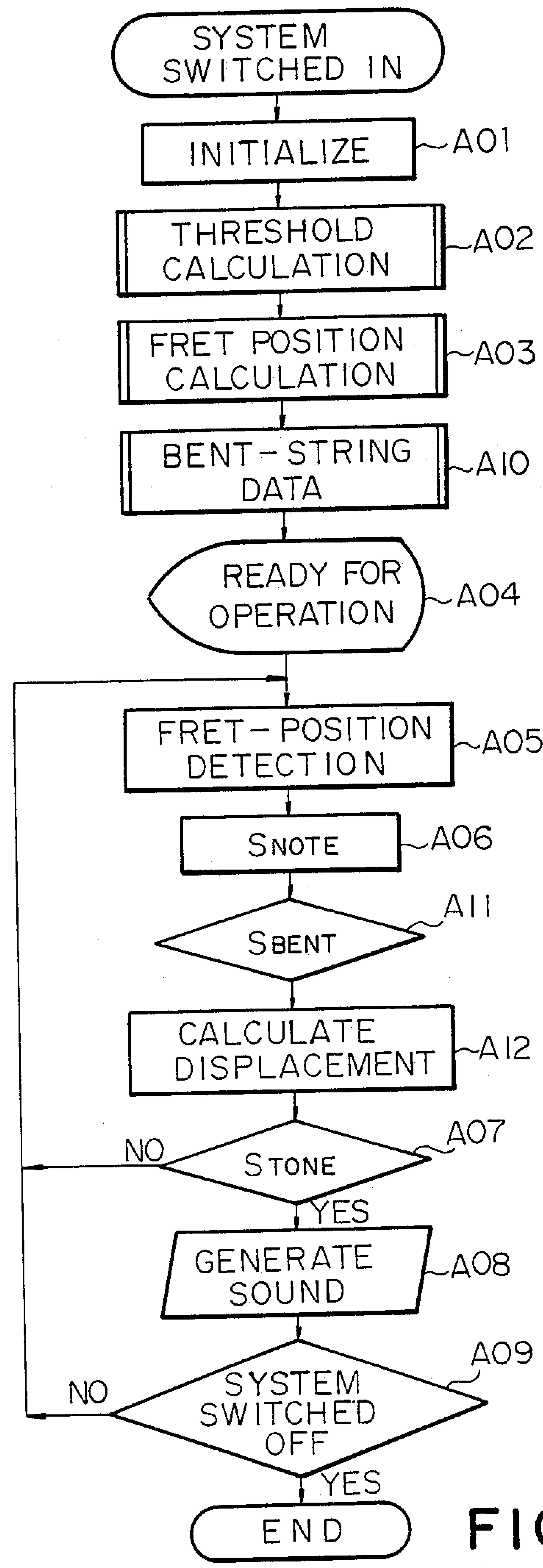

SYSTEM SWITCHED IN
INITIALIZE
A01
THRESHOLD CALCULATION
A02
FRET POSITION CALCULATION
A03
BENT-STRING DATA
A10
READY FOR OPERATION
A04
FRET-POSITION DETECTION
A05
SNOTE
A06
SBENT
A11
CALCULATE DISPLACEMENT
A12
STONE
A07
NO
YES
GENERATE SOUND
A08
SYSTEM SWITCHED OFF
A09
NO
YES
END

FIG. 7

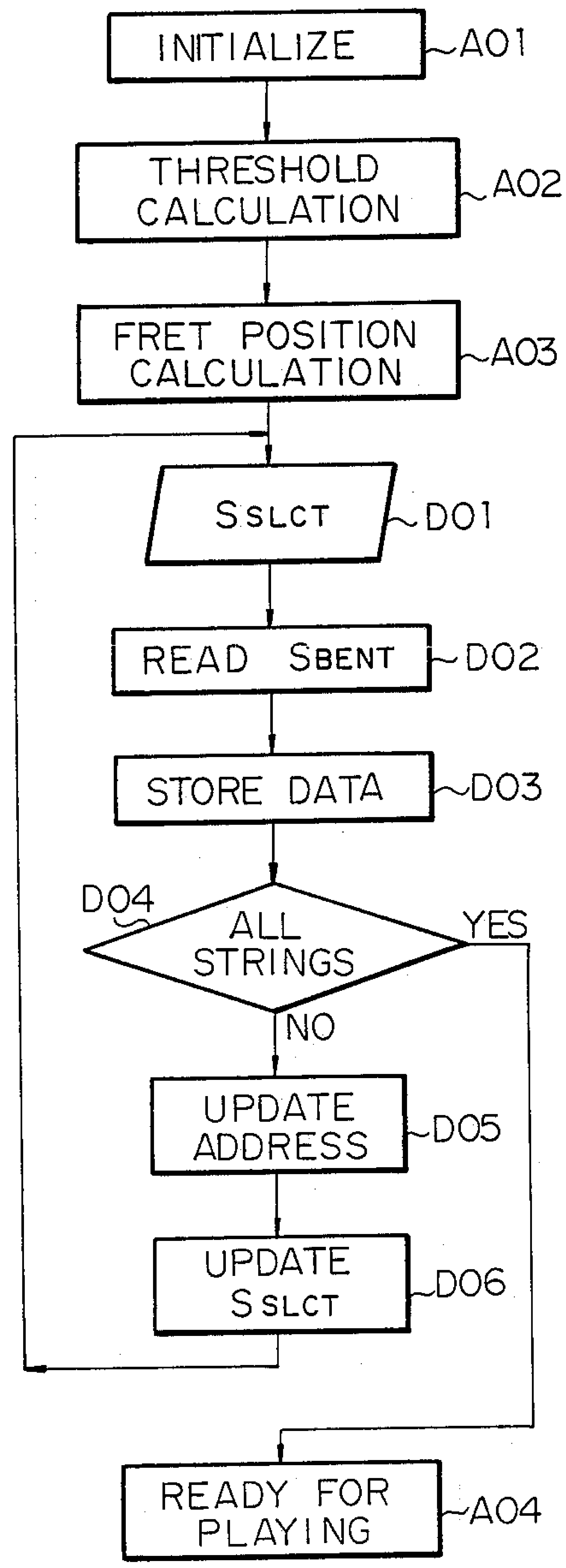

INITIALIZE
A01
THRESHOLD CALCULATION
A02
FRET POSITION CALCULATION
A03
SSLCT
D01
READ SBENT
D02
STORE DATA
D03
D04
ALL STRINGS
YES
NO
UPDATE ADDRESS
D05
UPDATE SSLCT
D06
READY FOR PLAYING
A04

FIG. 8

ELECTRONIC MUSICAL INSTRUMENT HAVING PLAYING AND PARAMETER ADJUSTMENT MODES

FIELD OF THE INVENTION

The present invention relates to an electronic sound-producing system including a musical instrument of the fretted and stringed type in addition to a signal controlled tone generator. More particularly, the present invention relates to a fretted and stringed musical instrument to form part of such a sound-producing system. An electric or electronic musical instrument to which the present invention appertains is of the fretted and stringed type and may thus be by way of example of the guitar, mandolin, banjo, balalaika or lute type.

BACKGROUND OF THE INVENTION

With a fretted and stringed electric or electronic musical instrument, musical sound is produced with various tones generated through detection of the timings at which strings are picked and the locations of the fret members against which the strings being picked are pressed on the fingerboard. The timing at which a string is picked can be detected by the use of an electromagnetic pickup device responsive to relatively low frequency vibrations of the string. On the other hand, the location of the fret member with which a string is pressed into contact is detected by a fret-position detector using piezoelectric transducer elements respectively engaging the strings of the musical instrument. Each of the piezoelectric transducer elements is electrically activated to produce supersonic vibrations in the associated string and the supersonic vibrations thus produced in the string are transmitted to the fret member with which the string is currently pressed into contact. The vibrations which have reached the particular fret member are then reflected from the fret member and are transmitted backwardly to the piezoelectric transducer element. The supersonic vibrations returned to the piezoelectric transducer element mechanically activate the transducer element to produce an electric output signal when the vibrations are received by the transducer element. The signal thus produced by the piezoelectric transducer element is monitored to determine the time interval intervening between the generation of the supersonic vibrations in the sound and the generation of the signal by the supersonic vibrations returned to the transducer element. An electronic musical instrument of this type is disclosed in U.S. Pat. No. 4,723,468.

The fret-position detector used in a prior-art electronic musical instrument of the described type depends for its operation on the period of time for which supersonic vibrations are transmitted to and from a fret member. For this reason, it is of critical importance for the reliability of operation of the instrument that the supersonic vibrations echoed from the fret member be strictly discriminated from various spurious vibrations which may be transmitted to the piezoelectric transducer element to act as noises to the echoed signal vibrations. The spurious vibrations which may be transmitted to the piezoelectric transducer element include vibrations echoed from a bridge member carrying the piezoelectric transducer elements of the fret-position detector per se. Such spurious vibrations are produced in the bridge member in direct response to the supersonic vibrations generated in the transducer elements and are reflected

from the bridge member directly to each of the transducer elements.

To eliminate the effects of such noise vibrations which may be transmitted to the piezoelectric transducer elements of the fret-position detector, the electric output signal produced by each of the transducer elements is analyzed to detect the cyclically occurring peaks of the signal waveform and determine the time interval intervening between successive two of the peaks detected. A problem still arises in this manner of detecting the fret positions because, primarily, the peaks of the signal waveform produced by the fret-position detector are subject to irregular variation depending on the conditions in which the string through which the supersonic vibrations are transmitted is held in contact with the fret member to which the vibrations are transmitted. Such irregular variation in the peaks of the signal waveform may cause an error in the time interval determined on the basis of the signal from the fret-position detector. When such an error is grown to a critical degree after the instrument is used for an extended period of time, deviation may be caused between the note of the sound intended to be produced by the player of the instrument and the note of the sound actually produced by the instrument in response to the signal from the fret-position detector.

The present invention first contemplates elimination of these drawbacks of a prior-art electronic musical instrument using a known fret-position detector. It is, accordingly, an important object of the present invention to provide an electronic musical instrument in which the location of the fret member with which a string being picked is pressed into contact can be accurately determined without respect to the spurious vibrations which may be transmitted to the piezoelectric transducer elements of the fret-position detector included in the instrument.

There is another important problem which results from the fact that the fret-position detector depends for its operation on the time interval for which supersonic vibrations are transmitted to and from a fret member. Such a time interval is however subject to fluctuations due to deformation of the neck portion of the instrument as caused by the tensions maintained in the strings and to lateral displacement of the strings on the fret members. In case such fluctuations in the time interval are of a critical degree, deviation may also be caused between the note of the sound intended to be produced by the player of the instrument and the note of the sound actually produced by the instrument in response to the signal from the fret-position detector.

Thus, the present invention further contemplates elimination of such a drawback of a prior-art electronic musical instrument using a known fret-position detector. Accordingly, it is another important object of the present invention to provide an electronic musical instrument capable of accurately determining the location of a fret member without respect to the fluctuations which may be caused in the time interval determined by the fret-position detector included in the instrument.

In the meantime, there is known and used a "bent-string" playing technique with which a string is forced to sidewise slide on a fret member to produce a rising intonation. When such a technique is used during playing of a musical instrument having a fret-position sensor of the described nature, the sensor could not detect the mode of playing and for this reason the sound producing system could not produce the player's intended rising intonation. This is primarily because of the fact that the sensor depends for its operation merely on the period of time for which vibrations are transmitted to a fret member and backwardly from the fret member to the sensor. To eliminate such an inconvenience, an electronic musical instrument has been proposed which uses probe elements respectively held in engagement with the individual strings of the instrument. Each of the probe elements is located to intercept the path of light in a photocoupling unit which thus produces an electric signal variable with the lateral displacement of the string engaged by the associated probe element. An electronic musical instrument of this type is disclosed in Japanese patent application No. 62-083289.

The features of these two types of prior-art musical instruments could be combined to provide an electronic musical instrument allowing the player of the instrument to use the bent-string playing technique. In such an electronic musical instrument having the combined features of the two types of prior-art instruments, the signal produced from the photocoupling unit is produced upon comparison with a signal produced when the associated string remains in a non-bent state extending straight on a fret member. It is thus of critical importance that the value of the signal produced responsive to a string in such a non-bent state be accurately determined by the photocoupling unit. Difficulties are however encountered in accurately determining such a value because, primarily, of the fact that the lateral position of each string on a fret member is subject to variation depending on the tension in the string.

The present invention further contemplates elimination of such a drawback of an electronic musical instrument having the combined features of the two types of prior-art instruments. It is, accordingly, still another important object of the present invention to provide an improved electronic musical instrument having a bent-string sensor and capable of accurately determining a non-bent state of a string.

SUMMARY OF THE INVENTION

In accordance with one outstanding aspect of the present invention, these and other objects are accomplished in an electronic musical instrument having a parameter adjustment mode and a playing mode of operation, comprising (a) a plurality of fret members located at predetermined spacings; (b) a string stretched over the fret members and engageable to any of the fret members; (c) vibration generating and receiving means for producing supersonic vibrations in the string and receiving the supersonic vibrations reflected from any of the fret members through the string, the supersonic vibrations transmitted from the vibration generating and receiving means being reflected from a fret member engaged by the string; and (d) fret-position detecting means responsive to the supersonic vibrations transmitted from and reflected to the vibration generating and receiving means for detecting the fret member engaged by the string, the fret-position detecting means comprising means for detecting the waveform of the supersonic vibrations reflected to the vibration generating and receiving means, means for detecting a peak value of the waveform, means for determining a threshold value in respect of the string during the parameter adjusting mode of operation, memory means for storing the threshold value during, and means for comparing a peak value detected from the waveform with the threshold value during the playing mode of operation for determining whether or not the waveform is of the supersonic vibrations reflected from any of the fret members.

In accordance with another outstanding aspect of the present invention, there is provided an electronic musical instrument having a parameter adjustment mode and a playing mode of operation, comprising (a) a plurality of fret members located at predetermined spacings; (b) a string stretched over the fret members and engageable to any of the fret members; (c) vibration generating and receiving means for producing supersonic vibrations in the string and receiving the supersonic vibrations reflected from any of the fret members through the string, the supersonic vibrations transmitted from the vibration generating and receiving means being reflected from a fret member engaged by the string; and (d) fret-position detecting means responsive to the supersonic vibrations transmitted from and reflected to the vibration generating and receiving means for detecting the fret member engaged by the string, the fret-position detecting means comprising memory means for storing data representative of a reference time interval for which the supersonic vibrations are transmitted from and reflected to the vibration generating and receiving means in respect to each of the fret members during the parameter adjusting mode of operation, first detecting means for detecting the time interval for which the supersonic vibrations are transmitted from and reflected to the vibration generating and receiving means during the playing mode of operation, means for comparing the time interval detected by the first detecting means with the reference time interval during the playing mode of operation for thereby determining the fret member from which the supersonic vibrations are reflected to the vibration generating and receiving means, second detecting means for detecting the time interval for which the supersonic vibrations are transmitted from and reflected to the vibration generating and receiving means in respect of a selected one of the fret members during the parameter adjusting mode of operation, and means for producing time interval data on the basis of the time interval detected by the second detecting means and storing the time interval data into the memory means.

In accordance with still another outstanding aspect of the present invention, there is further provided an electronic musical instrument having a parameter adjustment mode and a playing mode of operation, comprising (a) a plurality of fret members located at predetermined spacings; (b) a string stretched over the fret members and engageable to any of the fret members, (c) vibration generating and receiving means for producing supersonic vibrations in the string and receiving the supersonic vibrations reflected from any of the fret members through the string, the supersonic vibrations transmitted from the vibration generating and receiving means being reflected from a fret member engaged by the string; (d) fret-position detecting means responsive to the supersonic vibrations transmitted from and reflected to the vibration generating and receiving means for detecting the fret member engaged by the string; (e) string displacement detecting means for detecting an amount of lateral displacement of the string on any of the fret members and producing data representative of the detected amount of lateral displacement of the string; (f) memory means for storing the data representative of the amount of lateral displacement detected with the string maintained in a non-bent state; and (g) means for comparing the amount of lateral displacement of the string from the data produced by the string displacement detecting means during the playing operation with the data stored in the memory means for thereby producing bent-string data representative of a corrected amount of lateral displacement of the string.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of a musical instrument according to the present invention will be more clearly understood from the following description taken in conjunction with the accompanying drawings in which:

FIG. **1** shows in a side elevation view a preferred embodiment of a fretted and stringed electronic musical instrument according to the present invention and in a block diagram the general circuit arrangement of the control system incorporated in the musical instrument;

FIG. **2** is a plan view showing an example of the general configuration of the data processor circuit which forms part of the control system of the musical instrument embodying the present invention;

FIG. **3** is a flowchart showing a main routine program which may be executed to achieve the major function of the first preferred embodiment of an electronic musical instrument according to the present invention;

FIG. **4** is a flowchart showing the details of a threshold calculating subroutine program which may be executed to determine and store threshold values used in the routine program illustrated in FIG. **3**, particularly in a fret-position detecting subroutine program thereof;

FIG. **5** is a flowchart showing the details of a fret-position calculating subroutine program which may be executed to produce and store fret position data used in the routine program illustrated in FIG. **3**, also particularly in a fret-position detecting subroutine program thereof;

FIG. **6** is a view similar to FIG. **1** but now shows in a side elevation view a second preferred embodiment of a fretted and stringed electronic musical instrument according to the present invention and in a block diagram of the general circuit arrangement of the control system incorporated in the musical instrument;

FIG. **7** is a flowchart showing a main routine program which may be executed to achieve the major function of the second preferred embodiment of an electronic musical instrument according to the present invention; and

FIG. **8** is a flowchart showing the details of an initial bent-string data forming subroutine program which may be executed in the routine program illustrated in FIG. **7**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The general arrangement of a preferred embodiment of a musical instrument according to the present invention will now be described in more detail with reference to FIG. **1**. The musical instrument herein shown is of the guitar type but may be understood to be representative of a fretted and stringed electric or electronic musical instrument of any of the types hereinbefore enumerated.

Referring to FIG. **1**, the musical instrument of the guitar type embodying the present invention comprises a body portion **10**, a neck portion **12** extending forwardly from the body portion **10**, and a head portion **14** further extending forwardly from the neck portion **12**. A plurality of or typically six strings **16** are anchored each at one end to a tailpiece **18** fixedly attached to the body portion **10** and have leading end portions rolled round tuning pegs **20** fitted to the head portion **14** to permit adjustment of the tension in each of the strings **16**. On the neck portion **12** of the instrument is mounted a fingerboard **22** on which a plurality of fret members **24** are located at predetermined spacings from one another.

The musical instrument further comprises a tone detector assembly **26** composed of a plurality of electromagnetic pickup elements respectively corresponding to the strings **16**. Each of the pickup elements of the tone detector assembly **26** is responsive to the vibrations of relatively low frequencies of the associated one of the strings **16** and, when the associated string **16** is picked by the player of the instrument, produces an output signal S_{TONE} indicative of the string **16** currently picked by the player and the time for which the particular string **16** is being picked.

The tone detector assembly **26** forms part of a control system of the musical instrument embodying the present invention, which control system further comprises a fret-position detector assembly **28** including a bridge member **30** fixedly attached to and extending laterally of the body portion **10** of the instrument. On the bridge member **30** are mounted a plurality of piezoelectric transducer elements **32** which are arranged along the bridge member **30** to correspond to the individual strings **16**, respectively.

The pickup elements of the tone detector assembly **26** are electrically connected to a tone generator circuit **34** which generates musical tones in response to the signals S_{TONE} respectively supplied from the pickup elements. On the other hand, the piezoelectric transducer elements **32** of the fret-position detector assembly **28** are electrically connected to a data processor circuit **36** through a wave separator circuit **38** or through the wave separator circuit **38** and an analog-to-digital (A/D) converter **40**. The data processor circuit **36** is further connected to the tone generator circuit **34**, which in turn is connected through an amplifier **42** to a sound system **44** which may be implemented by a speaker unit.

From the data processor circuit **36** is supplied a succession of driving pulses S_{DRV} to each of the piezoelectric transducer elements **32** through the wave separator circuit **38**. Each time a driving pulse S_{DRV} is supplied to the piezoelectric transducer elements **32**, each of the transducer elements **32** is electrically activated to generate vibrations of a predetermined supersonic (or ultra-audible) frequency of, for example, 450 KHz. The supersonic-frequency vibrations thus generated by each piezoelectric transducer element **32** are transmitted through the string **16** corresponding to the piezoelectric transducer element **32** to the fret member **24** with which the particular ring **32** is pressed into contact. The vibrations which have reached the fret member **24** are then reflected or "echoed" backwardly from the fret member **24** to the piezoelectric transducer element **32** and enable the transducer element **32** to produce an electric signal S_{FRET} when the vibrations reflected from the fret member **24** are received by the transducer element **32**. The electric signal S_{FRET} thus produced by each of the piezoelectric transducer elements is supplied in digitalized form to the data processor circuit **36** through the wave separator circuit **38** and by way of the analog-to-digital converter **40**. As noted previously, each of the piezoelectric transducer elements **32** receves not only the supersonic vibrations echoed from the fret member

24 but also the spurious vibrations produced in the bridge member 30 in direct response to the supersonic vibrations generated in the transducer elements 32 and reflected from the bridge member 30 further directly to each of the transducer elements 32.

From the electric signal S_{FRET} supplied from each of the piezoelectric transducer elements 32, the data processor circuit 36 detects the time duration for which the supersonic vibrations originating in the piezoelectric transducer element 32 have travelled from the transducer element 32 to the fret member 24 and backwardly from the fret member 24 to the transducer element 32. The time duration is variable with the distance of the fret member 24 from the piezoelectric transducer element 32 and is accordingly representative of the location of the fret member 24 with respect to the transducer element 24. The location of the fret member 24 pressed upon by a string 16 is in this manner detected from the electric signal S_{FRET} supplied from each of the piezoelectric transducer elements 32 respectively associated with the individual strings 16.

In this manner the data processor circuit 36 produces a sound note signal S_{NOTE} indicative of the note of the sound to be generated for each of the strings 16 and supplies the signal S_{NOTE} to the tone generator circuit 34. In response to the signal S_{NOTE} indicative of the note of the sound to be generated and the signal S_{TONE} indicative of the timing at which the sound is to be produced, the tone generator circuit 34 determines the sound to be generated with the particular note and at the particular timing. The tone generator circuit 34 then supplies an appropriate driver signal to the sound system 44 upon amplification by the amplifier 42 connected to the sound system 44.

FIG. 2 shows an example of the general configuration of the data processor circuit 36 which forms part of the control system of the musical instrument embodying the present invention.

As shown, the data processor circuit 36 comprises a microprocessor unit 46, a read-only memory (ROM) unit 48 storing a set of instructions for the program to be executed by the microprocessor unit 46, and a random-access memory (RAM) unit 50 for storing the data produced in or received by the microprocessor unit 46. These microprocessor unit 46, ROM unit 48 and RAM unit 50 are connected together through a data bus 52 through which instructions are to be accessed in the ROM unit and transmitted to the microprocessor unit 46 or data are to be transmitted from the microprocessor unit to the RAM unit 50. The data bus 52 is further connected through an input/output (I/O) buffer 52 to the tone generator circuit 34, wave separator circuit 38 and A/D converter 40 so that data may be exchanged between each of these circuits 34, 38 and 40 and the microprocessor unit 46 through the bus 52 and by way of the I/O buffer 52. Address signals are to be supplied from the microprocessor unit 46 to each of the ROM unit 48, RAM unit 50 and I/O buffer 54 through an address bus 56.

The RAM unit 50 has memory areas 50*a* and 50*b* reserved for storing data for use detecting the locations of the fret members 24 onto which the strings 16 being picked are pressed. Such data include threshold values calculated by the microprocessor unit 46 in respect of the individual strings 16, respectively, of the instrument and stored in the memory area 50*a*. In the other memory area 50*b* are stored fret position data indicating the locations of the fret members 24 in terms of the time intervals for which supersonic vibrations are transmitted from and reflected to the piezoelectric transducer elements 32.

A routine program which may be executed by the microprocessor unit 46 to achieve the major function of the electronic musical instrument embodying the present invention will be hereinafter described with reference to the flowchart of FIG. 3.

The microprocessor unit 46 starts the execution of the main routine program shown in FIG. 3 when the system is initially switched in and at step A01 initializes the whole system in accordance with the instructions stored in the ROM unit 48. After the whole system is thus initialized, the microprocessor unit 46 proceeds to a threshold calculating subroutine program A02 to determine threshold values (V_T) for the individual strings 16, respectively, and store the threshold values into the memory area 50*a* of the RAM unit 50. The details of this threshold calculating subroutine program A02 will be hereinafter described with reference to FIG. 4.

Upon termination of the threshold calculating subroutine program A02, the microprocessor unit 46 proceeds to a fret-position calculating subroutine program A03 to determine fret position data indicating the locations of the fret members 24 in terms of the time intervals for which supersonic vibrations are transmitted from and reflected to the piezoelectric transducer elements 32. The fret-position calculating subroutine program A03 is followed by a step A04 to indicate that the instrument is ready to operate. Such an indication may be given by the glowing or flickering of any light emitter element (not shown) sucha as a light emitting diode (LED) provided on the instrument. The step A01 and subroutine programs A02 and A03 provide a parameter adjustment mode of operation of the instrument. The microprocessor unit 46 then proceeds to a loop of steps which provide a playing mode of operation of the instrument.

During the playing mode of operation of the instrument, the microprocessor unit 46 executes a fret-position detecting subroutine program A05 in accordance with any instructions fetched from the ROM unit 468. In this fret-position detecting subroutine program A05, the microprocessor unit 46 supplies driving pulses S_{DRV} successively to each of the piezoelectric transducer elements 32 of the fret-position detector assembly 28 through the wave separator circuit 38 shown in FIG. 1. Each time a driving pulse S_{DRV} is thus supplied to the piezoelectric transducer elements 32 concurrently, each of the transducer elements 32 is electrically activated to generate supersonic vibrations. The supersonic vibrations thus generated by each piezoelectric transducer element 32 are transmitted through the string 16 engaged by the piezoelectric transducer element 32 to the fret member 24 with which the particular string 32 is pressed into contact. The vibrations which have reached the fret member 24 are then reflected or echoed backwardly from the fret member 24 to the piezoelectric transducer element 32 and enable the transducer element 32 to produce an analog electric signal S_{FRET} when the vibrations reflected from the fret member 24 are returned to the transducer element 32.

Simultaneously when a driving pulse S_{DRV} is issued from the microprocessor unit 46, the internal timer of the microprocessor unit 46 starts the counting of time and continues the counting of time until the supersonic vibrations echoed from any of the fret members 24 are received by the piezoelectric transducer element 32 in which the supersonic vibrations originated. As noted previously, the vibrations which are received by the piezoelectric transducer element **32** contain not only the supersonic vibrations echoed from the fret member **24** but the spurious vibrations reflected from the bridge member **30** forming part of the fret-position detector assembly **28** per se. Such spurious vibrations are generated in the bridge member **30** in direct response to the supersonic vibrations generated in the transducer elements **32** and reflected from the bridge member **30** further directly to each of the transducer elements **32**.

The analog electric signal S_{FRET} produced by each of the piezoelectric transducer elements **32** is passed through the wave separator circuit **38** to the A/D converter **40**. A series of digital signals is produced by the A/D converter **50** from the analog signals S_{FRET} respectively output from the piezoelectric transducer elements **32** associated with the individual strings **16** are supplied in succession to the microprocessor unit **46** of the data processor circuit **36** through the I/O buffer **54**. Until the supersonic vibrations transmitted from the piezoelectric transducer element **32** of the fret-position detector assembly **28** are reflected from any of the fret members **24** and are received by the transducer elements **32**, the piezoelectric transducer element **32** is therefore responsive only to the vibrations echoed from the bridge member **30**. The analog output signal S_{FRET} from the piezoelectric transducer element **32** is variable voltage with the waveform of the vibrations received by the transducer element **32** and, thus, the series of digital signals converted therefrom is variable with the voltage of the signal S_{FRET}.

In response to each of the digital signals successively input through the I/O buffer **54**, the microprocessor unit **46** reads the threshold value stored in the memory area **50***a* of the RAM unit **50** in respect of the string **16** associated with the particular piezoelectric transducer element **32** and compares the data represented by the received digital signal with the threshold value thus read from the RAM unit **50**. In the absence of any supersonic vibrations reflected from the fret member **24**, the digital signal which has resulted from the supersonic vibrations echoed from the bridge member **30** can be easily and accurately discriminated from the digital signal which may otherwise be produced in response to the supersonic vibrations reflected from the fret member **24**. The digital signal resulting from the vibrations reflected from the bridge member **30** is thus rejected effectively as a result of the comparison thus made between the digital signal and the threshold value read from the RAM unit **50**.

In the meantime, the supersonic vibrations transmitted to and reflected from any of the fret members **24** will return to the piezoelectric transducer element **32**. At the point of time such vibrations are received by the piezoelectric transducer element **32**, the internal timer of the microprocessor unit **46** ceases the counting of time whereupon the microprocessor unit **46** calculates the period of time which has lapsed since the vibrations were initially generated in the piezoelectric transducer element **32**. The data thus produced as representing such a time interval is compared with a fret position data fetched from the memory area **50***b* of the RAM unit **50** to specifically determine the fret member **24** from which the supersonic vibrations have been reflected, viz., with which the string **16** associated with the piezoelectric transducer element **32** is currently held in contact.

After the fret member **24** against which the string **16** associated with each of the piezoelectric transducer elements **32** is currently held in contact is determined as above described, the microprocessor unit **46** proceeds to a sound note signal output step **A06** to output the signal S_{NOTE} indicative of the note of the sound to be generated for each of the strings **16**. The sound note signal S_{NOTE} thus produced by the microprocessor unit **46** is output from the data processor circuit **36** to the tone generator circuit **34** through the I/O buffer **54**. It is then tested at step **A07** whether or not there is the signal S_{TONE} supplied from the tone detector assembly **26** to the tone generator circuit **34**. If it is found at the step **A07** that there is such a signal produced with any of the strings **16** picked by the player, the microprocessor unit **36** of the data processor circuit **36** supplies the sound note signal S_{NOTE} to the tone generator circuit **34**. In response to the signal S_{NOTE} indicative of the note of the sound to be generated and the signal S_{TONE} indicative of the timing at which the sound is to be produced, the tone generator circuit **34** determines the sound to be generated with the particular note and at the particular timing. The tone generator circuit **34** then supplies at step **A08** an appropriate driver signal to the sound system **44** upon amplification by the amplifier **42** connected to the sound system **44**. Thereafter, the loop of the steps **A04** to **A08** which dictate the playing mode of operation of the instrument is repeated until it is found at step **A09** that the system is switched off.

The threshold values used in the routine program, particularly in the fret-position detecting subroutine program **A04** thereof are calculated by the microprocessor unit **46** in respect of the individual strings **16**, respectively, and are stored in the memory area **50***a* of the RAM unit **50**. Such threshold values V_T are calculated in the threshold calculating subroutine program **A02**, the details of which are depicted in the flowchart of FIG. **4**.

The execution of the threshold calculating subroutine program **A02** is started upon termination of the initializing of the system as at step **A01** of the main routine program described with reference to FIG. **3**. In the threshold calculating subroutine program **A02**, a scan signal S_{SCAN} consisting of a series of bits is output from the microprocessor unit **46** at step **B01**. The scan signal S_{SCAN} is supplied through the I/O buffer **54** and wave separator circuit **38** to the piezoelectric transducer element **32** associated with a specified first one of the strings **16** at step **B02**. Supersonic vibrations are thus produced in the particular piezoelectric transducer element **32** and are transmitted through the associated string **16** to any one of the fret members **24**. The vibrations which have reached one of the fret members **24** are reflected from the fret member **24** and are returned to the piezoelectric transducer element **32**, which then generates an analog output signal S_{FRET} in response to the supersonic vibrations thus received. The analog output signal S_{FRET} from the piezoelectric transducer element **32** is passed through the wave separator circuit **38** to the A/D converter **40** and is converted by the A/D converter **40** into a succession of digital signals. As noted previously, the piezoelectric transducer element **32** receives the supersonic vibrations reflected from the bridge member **30** before the vibrations transmitted toward the fret member **24** are reflected therefrom.

The series of digital signals output from the A/D converter **40** is variable with the voltage of the signal

S_{FRET} input to the A/D converter **40** and is variable with the waveform of the vibrations received by the transducer element **32**. Such digital signals are successively supplied to the microprocessor unit **46** of the data processor circuit **36** as at step **B03**, whereupon it is tested at step **B04** by the microprocessor unit **46** whether or not the signals received is indicative of a peak value (V_P) of the voltage varying with the waveform of the vibrations received by the transducer element **32**. While the voltage represented by the digital signals supplied to the microprocessor unit **46** is continuously varying, the answer for this step **B04** is given in the negative and, thus, the microprocessor unit **46** repeats the loop of the steps **B03** and **B04** until the answer for the step **B04** turns affirmative.

When it is confirmed at step **B04** that the signal S_{FRET} is indicative of a peak value V_P, then the microprocessor unit **46** proceeds to step **B05** to calculate a threshold value (V_T) which corresponds to the detected peak value. Such a threshold value V_T is calculated as a function of the detected peak value V_P typically in the form of a product of the peak value V_P multiplied by an appropriate constant (k) which is given experimentally. The threshold value V_T thus determined on the basis of the detected peak value V_P is stored at step **B06** into the memory area **50a** of the RAM unit **50** of the data processor circuit **36** at the address particularly assigned to the specified first one of the strings **16**.

The step **B06** is followed by a decision step **B07** at which is tested whether or not there have been determined the threshold values for all the strings **16** which are herein assumed to be provided as six in number. If it is determined at this step **B07** that there remains a threshold value to be determined for any other string **16**, the address to be accessed in the memory area **50a** of the RAM unit **50** during the next write cycle is incremented at step **B08** and then the microprocessor unit **46** reverts to step **B01** to repeat the loop of the steps **B01** to **B07** for another or specified second one of the strings **16**. When it is confirmed at step **B07** that threshold values have been determined and stored into the RAM unit **50** for all the strings **16**, the answer for the step **B07** is given in the affirmative so that the microprocessor unit **46** proceeds from the threshold calculating subroutine program **A02** to the subsequent fret-position calculating subroutine program **A03**.

FIG. **5** shows the details of a fret-position calculating subroutine program which may be executed to produce the fret position data used in the fret-position detecting subroutine program **A03** of the routine program illustrated in FIG. **3**. As noted previously, the fret position data calculated by the microprocessor unit **46** are stored in the memory area **50b** of the RAM unit **50**.

The execution of the fret-position calculating subroutine program **A03** is started subsequently to the threshold detecting subroutine program **A02** of the main routine program described with reference to FIG. **3**. Upon termination of the threshold detecting subroutine program **A02**, a scan signal S_{SCAN} consisting of a series of bits is output from the microprocessor unit **46** at step **C01**. The scan signal S_{SCAN} is supplied through the I/O buffer **54** and wave separator circuit **38** to the piezoelectric transducer element **32** associated with a specified first one of the strings **16** at step **B02**. In this instance, each of the strings **16** is disengaged from the fret members **24** except for a specified first one of the fret members **24** such as the fret member remotest from the fret-position detector assembly **28**. Supersonic vibrations are thus produced in the particular piezoelectric transducer element **32** and are transmitted to the specified first one of the fret members **24** through the associated string **16**. The vibrations which have reached the first one of the fret members **24** are reflected from the fret member **24** and are returned to the piezoelectric transducer element **32**, which then generates an analog output signal S_{FRET} in response to the supersonic vibrations thus received. The analog output signal S_{FRET} from the piezoelectric transducer element **32** is passed through the wave separator circuit **38** to the A/D converter **40** and is converted by the A/D converter **40** into a succession of digital signals. The digital signals output from the A/D converter **40** are successively supplied to the microprocessor unit **46** of the data processor circuit **36** as at step **C02**. The steps **C01** and **C02** of the subroutine program **A03** are thus similar to the steps **B01** and **B02**, respectively, of the threshold calculating subroutine program **A02** hereinbefore described with reference to FIG. **4**.

A driving pulse S_{DRV} is then issued from the microprocessor unit **46** the data processor circuit **36**, whereupon the internal timer of the microprocessor unit **46** starts the counting of time at step **C03** and continues the counting of time until the supersonic vibrations echoed from the specified first one of the fret members **24** are received by the piezoelectric transducer element **32** in which the supersonic vibrations originated. As noted previously, the vibrations which are received by the piezoelectric transducer element **32** contain not only the supersonic vibrations echoed from the fret member **24** but the spurious vibrations reflected from the bridge member **30** forming part of the fret-position detector assembly **28**.

The analog electric signal S_{FRET} produced by each of the piezoelectric transducer elements **32** is passed through the wave separator circuit **38** to the A/D converter **40**. A series of digital signals is produced by the A/D converter **50** from the analog signals S_{FRET} respectively output from the piezoelectric transducer elements **32** associated with the individual strings **16** are supplied in succession to the microprocessor unit **46** of the data processor circuit **36** through the I/O buffer **54**. Until the supersonic vibrations transmitted from the piezoelectric transducer element **32** of the fret-position detector assembly **28** are reflected from the specified first one of the fret members **24** and are received by the transducer elements **32**, the piezoelectric transducer element **32** is therefore responsive only to the vibrations echoed from the bridge member **30**.

In response to each of the digital signals successively input through the I/O buffer **54**, the microprocessor unit **46** tests at step **C04** whether or not the vibrations received by the piezoelectric transducer element **32** are those which have been reflected from the first one of the fret members **24**. For this purpose, the microprocessor unit **46** reads the threshold value stored in the memory area **50a** of the RAM unit **50** in respect of the specified first one of the strings **16** and compares the data represented by the received digital signal with the threshold value thus read from the RAM unit **50**. In the absence of any supersonic vibrations reflected from the fret member **24**, the answer for the step **C04** is given in the negative so that the microprocessor unit **46** repeats the step **C04** until the answer for the step turns affirmative.

When it is found at step **C04** that the supersonic vibrations transmitted to the first one of the fret members

24 are returned to and received by the piezoelectric transducer element 32, the internal timer of the microprocessor unit 46 ceases the counting of time at step C05 whereupon the microprocessor unit 46 calculates the period of time which has lapsed since the vibrations were initially generated in the piezoelectric transducer element 32. Then at step C06, the data thus produced as representing such a time interval is stored into the memory area 50*b* of the RAM unit 50 at the address assigned to the first one of the fret members and the first one of the strings 16. The step C06 is followed by a step C07 at which the address to be accessed in the memory area 50*b* of the RAM unit 50 during the next write cycle is incremented at step C07 and then the microprocessor unit 46 proceeds to step C08 at which the data produced as representing the time interval in respect of a specified second one of the fret members 24 is calculated by the microprocessor unit 46. The data thus determined for the second one of the fret members 24 is at step C09 stored into the memory area 50*b* of the RAM unit 50 at the address updated at step C07 and assigned to the second one of the fret members 24.

The step C09 is followed by a decision step C10 at which is tested whether or not there have been obtained the fret-position data for all the fret members 24 in regard to the first one of the strings 16. If it is determined at this step C10 that there remains a fret-position data to be obtained for any other fret member 24, the loop of the steps C07 to C10 is repeated until the answer for the step C10 is given in the affirmative. The microprocessor unit 46 then proceeds to step C11 to confirm whether or not there have been obtained the fret-position data for all the strings 16. If it is determined at this step C11 that there remains a fret-position data to be obtained for any other string 16, the loop of the steps C01 to C11 is repeated until the answer for the step C11 is given in the affirmative. When it is determined at step C11 that fret-position data have been obtained for all the string 16s, the microprocessor unit 46 proceeds from the fret-position calculating subroutine program A03 to the subsequent step A04 to indicate that the instrument is ready to operate.

FIG. 6 shows a second preferred embodiment of the present invention provided by an electronic musical instrument having the previously described combined features of the two types of prior-art instruments.

Referring to FIG. 6, the musical instrument according to the second preferred embodiment of the present invention is assumed to be basically similar to the instrument described with reference to FIG. 1 and comprises the tone detector assembly 26 and the fret-position detector assembly 28. The tone detector assembly 26 is connected to the tone generator circuit 34 and the fret-position detector assembly 28 connected to the data processor circuit 36 through the wave separator 38 and A/D converter 40.

The musical instrument shown in FIG. 6 further comprises a unitary or single-piece bridge member 58 located intermediate between the tone detector assembly 26 and the fingerboard 22 and fixedly attached to the body portion 10 of the musical instrument. The bridge member 58 extends laterally of the body portion 10 of the instrument and is engaged by the individual strings 16 extending from the tone detector assembly 26 toward the fingerboard 22.

The musical instrument shown in FIG. 6 further comprises a bent-string sensor assembly 60 located intermediate between the bridge member 58 and the fingerboard 22 and fixedly attached in its entirely to the body portion 10 of the musical instrument. The bent-string sensor assembly 60 includes a plurality of probe elements 62 respectively engaged by the individual strings 16 of the instrument. On the body portion 10 of the musical instrument are thus provided the tailpiece 18, fret-position detector assembly 28, tone detector assembly 26, bridge member 58 and bent-string sensor assembly 60 which are arranged to this sequence from the end of the body portion 10 toward the fingerboard 22 as shown.

As in the electrical arrangement of the musical instrument described with reference to FIG. 1, the tone detector assembly 26 is composed of pickup elements respectively associated with the strings 16 and adapted to produce signals S_{TONE} when the respectively associated strings 16 are picked individually. The signals S_{TONE} thus generated by the tone detector assembly 26 are supplied to the tone generator circuit 34 to enable the tone generator circuit 34 to generate musical tone signals in response to the signals S_{TONE}. To each of the piezoelectric transducer elements 32 of the detector assembly 28 is supplied a succession of driving pulses S_{DRV} from the data processor circuit 36 through the wave separator circuit 38. In response to each of these driving pulses S_{DRV}, each of the piezoelectric transducer elements 32 of the detector assembly 28 generates vibrations of a predetermined supersonic frequency within a range of from 400 KHz to 450 KHz as previously noted. The supersonic-frequency vibrations generated by each piezoelectric transducer element 32 are transmitted through the string 16 engaged by the transducer element 32 and via the bridge member 58 and bent-string sensor assembly 60 to the fret member 24 against which the particular string 32 is currently pressed. The vibrations which have reached the fret member 24 are then reflected backwardly from the fret member 24 to the piezoelectric transducer element 32 via the bent-string sensor assembly 60 and bridge member 58 and enable the piezoelectric transducer element 32 to produce an electric signal S_{FRET} when the vibrations transmitted backwardly through the string 16 reach the piezoelectric transducer element 32. In the electrical arrangement of the musical instrument according to the second preferred embodiment of the present invention, the bent-string sensor assembly 60 is connected through an A/D converter 64 and a multiplexer 66 to the data processor circuit 36. The functions of these A/D converter 64 and multiplexer 66 will be described later.

The unitary bridge member 58 located intermediate between the tone detector assembly 26 and bent-string sensor assembly 60 as above described is adapted to pass supersonic-frequency vibrations of the strings 16 from the piezoelectric transducer elements 32 of the fret-position detector assembly 28 to the bent-string sensor assembly 60 without damping and reflecting the vibrations. In response to the low-frequency vibrations produced in the strings 16 when the strings 16 are picked by the instrument player's fingers or fingernails, the bridge member 58 dampens out such low-frequency vibrations and isolates the vibrations from the bent-string sensor assembly 60. The bridge member 58 is further effective to take up lateral displacement of the strings 16 to prevent such displacement from being transmitted to the bent-string sensor assembly 60. The bridge member 58 to achieve these functions is formed typically of acrylonitrile-butadienestyrene (ABS) copolymer.

Each of the probe elements **62** of the bent-string sensor assembly **60** is rockably supported on a pivot shaft fixed with respect to the body portion **10** of the instrument and has a lower portion movably located between a light emitter element and a photoelectric transducer constituting a photocoupling unit, though not shown in the drawings. The light emitter element may be implemented by a light emitting diode and the photoelectric transducer element implemented by a photodiode. Each probe element **62** is engaged at its upper end with one of the strings **16** and is thus forced to turn on the pivot shaft when the associated string **16** is caused to sidewise slide on the fret member **24** with which the string **16** is held in contact. With the probe element **62** thus turned about the axis of the pivot shaft, the sectional area of the path of light from the light emitter element toward the photoelectric transducer element of the photocoupling unit varies with the angle of turn of the probe element. This results in a change in the quantity of light incident on the photoelectric transducer element and, accordingly, the photocoupling unit produces an analog electric signal S_{BENT} which is variable with the angle of turn of the probe element and thus the amount of lateral displacement of the string **16** on the fret member **24.** The analog signal S_{BENT} supplied from the photocoupling unit is supplied to the multiplexer **66** after being digitalized by the A/D converter. For further details of the bent-string sensor assembly **60**, reference may be made to Japanese Patent Application No. 62-083289.

A routine program which may be executed by the microprocessor unit **46** to achieve the major function of the electronic musical instrument according to the second preferred embodiment of the present invention as above described is shown in the flowchart of FIG. **7.** The routine program herein shown includes all the steps of the program described with reference to FIG. **3** and additionally has an initial bent-string data forming subroutine program **A10** which intervenes between the subroutine program **A03** and step **A04** and steps **A11** and **A12** which intervene between the steps **A06** and **A07** of the routine program illustrated in FIG. **3.** The initial bent-string data forming subroutine program **A10** is executed to provide data relating to the amount of displacement of a bent string as will be described in more detail with reference to FIG. **8.**

After the sound note signal S_{NOTE} produced by the microprocessor unit **46** is output from the data processor circuit **36** to the tone generator circuit **34** through the I/O buffer **54** at step **A06**, the microprocessor unit **46** supplies to the multiplexer **66** an address signal assigned to each of the photocoupling units of the bent-string sensor assembly **62** to read data output from the multiplexer **66.** It is then tested at the additional step **A11** whether or not the signal S_{BENT} is contained in the data output from the multiplexer **66** and originating in any of the photocoupling units of the bent-string sensor assembly **60.** If it is found at this step **A11** that there is present the signal S_{BENT} in regard to any of the strings **16,** the microprocessor unit **46** calculates the amount of lateral displacement of the string **16** from the signal S_{BENT} and transmits data representative of the amount of displacement to the tone generator circuit **34** through the I/O buffer **54** at step **A12.** It is thereafter tested at step **A07** whether or not there is the signal S_{TONE} supplied from the tone detector assembly **26** to the tone generator circuit **34** as previously described with reference to FIG. **3.**

Turning to FIG. **8**, the initial bent-string data forming subroutine program **A10** is executed subsequently to the fret-position calculating subroutine program **A03** to provide data relative to the amount of displacement of a bent string. Such a subroutine program **A10** starts with a step **D01** at which a string select signal S_{SLCT} is supplied from the microprocessor unit **46** of the data processor circuit **36** to the multiplexer **66** through the I/O buffer **54**a to select a specified first one of the strings **16.** A signal S_{BENT} is then output from the photocoupling unit associated with the selected string **16** with the string maintained in a non-bent state of the string **16** and is, after being digitalized by the A/D converter **64**, passed to the multiplexer **66.** The step **D01** is followed by a step **D02** at which the microprocessor unit **46** reads the data thus supplied to the multiplexer **66** and is stored at subsequent step **D03** into a predetermined memory area (not shown) of the RAM unit **50** at the address particularly assigned to the specified first one of the strings **16** .

The step **D03** is followed by a decision step **D04** at which it is tested whether or not the data relating to the non-bent states of all the strings **16** have been stored into the RAM unit **50.** If it is determined at this step **B07** that there remains data to be obtained for any other string **16**, the address to be accessed in the RAM unit **50** during the next write cycle is incremented at step **D05** and then the string select signal S_{SLCT} from the microprocessor unit **46** is updated to select another string **16.** The microprocessor unit **46** then reverts to step **D01** to repeat the loop of the steps **D01** to **D06** for another string **16.** When it is confirmed at step **D04** that the data for all the strings **16** have been stored into the RAM **50,** the answer for the step **D04** is given in the affirmative so that the microprocessor unit **46** proceeds from the initial bent-string data forming subroutine program **A04** to the subsequent step **A04** of the main routine program illustrated in FIG. **7.**

What is claimed is:

1. An electronic musical instrument having a parameter adjustment mode and a playing mode of operation, comprising

(a) a plurality of fret members located at predetermined spacings;

(b) a string stretched over said fret members so that a player's depression of the string causes contact between the string and at least one of said fret members,

(c) vibration generating and receiving means for producing supersonic vibrations having a variable waveform in said string and receiving the supersonic vibrations reflected from any of said fret members through said string, the supersonic vibrations transmitted from said vibration generating and receiving means being reflected from a fret member contacted by said string; and

(d) fret-position detecting means responsive to the supersonic vibrations transmitted from and reflected to said vigration generating and receiving means for detecting said fret member contacted by said string, said fret-position detecting means comprising

means for detecting the waveform of the supersonic vibrations reflected to said vibration generating and receiving means,

means for detecting a peak value of said waveform, means for determining a threshold value of said waveform in respect to said string during said parameter adjusting mode of operation, and

memory means for storing said threshold value,

means for comparing a peak value detected from said waveform with said threshold value during said playing mode of operation for determining whether or not the waveform is of the supersonic vibrations reflected from any of said fret members.

2. An electronic musical instrument having a parameter adjustment mode and a playing mode of operation, comprising

(a) a plurality of fret members located at predetermined spacings;

(b) a string stretched over said fret members so that a player's depression of the string causes contact between the string and at least one of said first members,

(c) vibration generating and receiving means for producing supersonic vibrations in said string and receiving the supersonic vibrations reflected from any of said first members through said string, the supersonic vibrations transmitted from said vibration generating and receiving means being reflected from a fret member contacted by said string; and

(d) fret-position detecting means responsive to the supersonic vibrations transmitted from and reflected to said vibration generating and receiving means for detecting said fret member contacted by said string, said fret-position detecting means comprising

memory means for storing data representative of a reference time interval for which the supersonic vibrations are transmitted from and reflected to said vibration generating and receiving means in respect of each of said fret members during said parameter adjusting mode of operation,

first detecting means for detecting the time interval for which the supersonic vibrations are transmitted from and reflected to said vibration generating and receiving means during said playing mode of operation,

means for comparing the time interval detected by said first detecting means with said reference time interval during said playing mode of operation for thereby determining the fret member from which the supersonic vibrations are reflected to said vibration generating and receiving means,

second detecting means for detecting the time interval for which the supersonic vibrations are transmitted from and reflected to said vibration generating and receiving means in respect of a selected one of said fret members during said parameter adjusting mode of operation, and

means for producing time interval data on the basis of the time interval detected by said second detecting means and and storing said time interval data into said memory means.

3. An electronic musical instrument having a parameter adjustment mode and a playing mode of operation, comprising

(a) a plurality of fret members located at predetermined spacings;

(b) a string stretched over said fret members so that a player's depression of the string causes contact between the string and at least one of said fret members,

(c) vibration generating means for producing supersonic vibrations in said string;

(d) a fret-position detecting means responsive to the supersonic vibrations transmitted from said means for detecting the fret member contacted by said string;

(e) string displacement detecting means for detecting an amount of lateral displacement of said string on any of said fret members and producing data representative of the detected amount of lateral displacement of said string;

(f) memory means for storing said data representative of the amount of lateral displacemment detected with said string maintained in an non-bent state; and

(g) means for comparing the amount of lateral displacement of said string from the data produced by said string displacement detecting means during said playing operation with the data stored in said stored means for thereby producing bent-string data representative of a corrected amount of lateral displacement of said string.

4. An electronic musical instrument as set forth in claim 3, in which said vibration generating means is operative to produce said supersonic vibrations in said string and further to receive the supersonic vibrations reflected from any of said fret members through said string, the supersonic vibrations transmitted from said vibration generating and receiving means being reflected from a fret member contacted by said string.

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